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## Monitoring Residential Quality for the Elderly Using a Geographical Information System

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**ABSTRACT** *The population in Europe, and even more so in The Netherlands, is ageing rapidly. Concurrently, in the light of severe budget deficits, the Dutch government's elderly care service policy has reduced the number and the capacity of elderly care services, such as old people's homes and nursing homes. The consequence of this national policy, with regard to housing for the elderly, is that the elderly need to remain independent in their own residential neighbourhood for more years than they did in the past. However, in urban and suburban areas, the elderly who live independently face an increasing number and range of problems, such as poor quality of dwellings, disappearance of neighbourhood facilities, increasing fear of crime, etc. In order to maintain the quality of the daily living environment of the elderly, urban planners and policy makers need to have access to proper information about processes and developments in the residential environment of the elderly. This information is related to physical and social characteristics of the residential area and its inhabitants. The use of modern information technologies to handle the associated multidimensional data, information and knowledge is therefore necessary. The objective of this paper is to discuss some critical topics related to the development of a computer-based system for public policy making concerning the quality of the residential environment for the elderly. Successful implementation of this system depends on a careful preliminary assessment of the type of system required to meet the demands of the end-user(s). The creation of an accurate functional design is essential and should be discussed in both the context of the technical requirements and the context of the end-user(s). Therefore, perspectives of different people involved should be taken into account for the development of public policy analysis systems. This has resulted in a new information tool. In the paper, this tool, coined RELEVANT (REsidential Location EValuation and ANalysis Tool), a GIS-based system for public policy analysis in the field of residential monitoring in the city of Amsterdam, is presented. The essential components of this policy support system—data, models and user interface—will be outlined in more detail. The added value of the GIS-like functions in this system is assessed as well with a particular view to transferability of the method used.*

### Introduction

The population in Europe, and even more so in The Netherlands, is ageing rapidly. An increase in life expectancy and a decrease in birth rates are leading to an explosive increase of persons of 55 years of age and older, generally regarded as 'the elderly' (or the 'silver' generation). Within this group, 'double

ageing' is also taking place, while the population of the 'old' elderly within the total elderly population is increasing even more rapidly (Vollering, 1991). Concurrently, the Dutch government's elderly care service policy has reduced the number and the capacity of elderly care services, such as old people's homes and nursing homes. The consequence of this national policy, with regard to housing, is that the elderly need to remain independent in their own residential neighbourhood for more years than they did in the past. In this context also the increasing differentiation in housing demands among the elderly population is leading towards a growing demand for independent housing possibilities.

The above observations are not only typical of The Netherlands, but mirror a general phenomenon in most European countries. According to Fokkema *et al.* (1996), the general housing behaviour and residential patterns of the elderly are different in several respects:

- The elderly are less likely to move house compared with other age-groups and hence attach a high value to residential quality of life.
- Persons aged 70 years or older are more often facing a forced move, and in that case the free choice of another house is often an illusion.
- There is an increasing trend among elderly people to leave the big cities and to move to suburban or even rural areas.

We may thus conclude that residential quality of life and environmental attractiveness have high relevance for the elderly generation. However, in urban and suburban areas, the elderly who live independently face an increasing number and range of problems. A notable shortage of suitable dwellings exists, especially in older urban areas. The quality of dwellings is often insufficient owing to poor technical quality, poor accessibility due to steep and narrow staircases, and sometimes lack of amenities such as a shower or bath. Furthermore, a decent residential environment is often lacking. For example, the gradual disappearance of small neighbourhood shops and post offices has a negative impact, especially for less mobile inhabitants who are often 'nearby orientated'. Increasing fear of crime, threatening behaviour and violence in the streets diminish the interaction possibilities of the elderly and devalue their daily living environment.

These phenomena raise various kinds of questions, such as: In what way can the local environment be adjusted to the needs of the elderly? How can we assess the residential needs and preferences of the elderly? And are there appropriate policy tools to influence the geographical patterns of elderly movers? Such questions are faced by urban planners and policy makers in all countries.

In order to offer older residents a future perspective in a decent residential environment, urban planners and policy makers need to have access to relevant information regarding developments in the daily living environment of the elderly. A computer-based system that offers possibilities to assess urban and residential quality indicators may be useful to monitor dynamic developments in the urban environment and to evaluate future policy actions. Such a system should inform urban planners and policy makers about positive and negative developments in both time and space and should offer relevant guidelines for policy making.

In this context, The Geographical Information System (GIS) seems to be a new technology that offers promising possibilities to integrate multidimensional data

on the physical and social characteristics of the residential environment of the elderly. The GIS offers the capabilities to store, manage, integrate and visualize spatial and non-spatial data. In particular, exploring spatial or geographical patterns of locational suitability, equity, accessibility etc., then becomes easy through map display and interactive map use.

The main objective of this paper is to illustrate some important aspects of the functional requirements, conceptual architecture and implementation of a GIS-based policy support system. Specific attention in this paper will be given to the integration of GIS technology and public policy analysis. This will be illustrated with an example of a GIS-based system for the assessment and monitoring of residential quality for elderly housing. This model-based GIS, called RELEVANT (REsidential Location EVALuation and ANalysis Tool), offers interactive access to data and models and multi-perspective views on spatial and non-spatial data through visualization by means of maps, graphs and tables. Even though the present paper focuses attention on the Dutch context, it is noteworthy that the phenomenon studied is fairly universal all over Europe. The GIS-based tool developed and described in the paper can easily be applied elsewhere, so that the methodology used for assessing and monitoring residential quality in the elderly segment is in principle widely applicable.

The paper is organized as follows. First, some general remarks will be made on residential quality assessment with a particular view to indicators of urban and residential quality and urban planning concepts concerning residential planning for elderly housing in The Netherlands. Then, computer-based instruments that may support urban planning and policy making are discussed from the perspective of monitoring residential quality. Next, the architecture and basic components of the GIS-based system RELEVANT—data, models and user interaction—will be discussed in more detail from a functional point of view. The use of RELEVANT is illustrated with an application in the city of Amsterdam. Finally, some concluding remarks will be made.

### **Residential Quality Assessment for Elderly Housing**

Over the past decades, planning concepts of elderly housing in The Netherlands shifted from the planning of institutional housing—old people's homes and nursing homes—towards planning concepts of independent housing with a focus on the design of buildings and dwellings. Recently, Dutch urban planning and management emphasized the neighbourhood as the geographical unit to study and monitor the living environment of the elderly and to obtain continuity of individual lifestyles. Local government in The Netherlands has adopted a housing policy of independent housing of elderly households in their own neighbourhood. Therefore, from the perspective of urban planning, the quality of the daily living environment of the elderly requires careful attention. The quality of living or 'life quality' has intensive attention in the social sciences (Pacione, 1981; Rogerson *et al.*, 1989). There is still a public and academic debate going on about the definition and measurement of quality of life. Various lists with social indicators exist, which refer to not only to the environment where people live (such as air and water pollution, poor housing), but also to the characteristics of individuals (such as health or educational achievement). As urban planning should provide a framework for the design and planning of residential living space, it can only affect a part of people's well-being and the

well-being of the elderly. The residential environment not only affects the physical well-being of the elderly, but also the social aspects of their lives (Burby & Rohe, 1990). Satisfaction with the neighbourhood and the housing situation are examples of important factors that can be influenced by urban planners and policy makers.

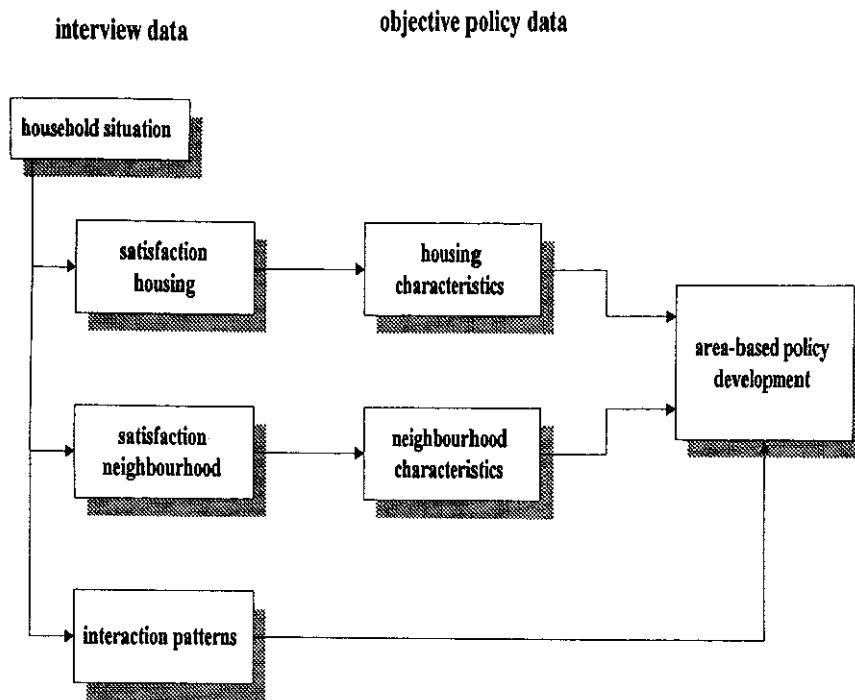
In The Netherlands, the concept of 'residential zoning for elderly', developed by planners of the PPD Noord-Holland (1989), is a planning concept for residential quality assessment. This concept is offering a framework to monitor and guarantee the possibilities for the elderly to live independently in a 'friendly' residential neighbourhood. Originally, residential areas for the elderly were defined as "areas with suitable and affordable dwellings, situated within 500 metres walking distance—or 400 metres as the crow flies—of services for the elderly: shops, public transport, medical facilities, post office and green areas. At the same time, these areas have by no means a homogeneous population of elderly, but are built up heterogeneously" (PPD, 1989).

Consequently, in considering housing for the elderly, planners need to focus their attention on both the physical and social characteristics of residences (Burby & Rohe 1990). Residential zoning for the elderly addresses this need, because it is adapted to local circumstances and qualifies areas according to their suitability for elderly housing based on physical and social characteristics. Physical characteristics of the neighbourhood are measured with indicators of accessibility to several important shopping facilities, care services centres and recreational services. The availability of suitable dwellings, defined and selected on their physical characteristics such as ground floor accessibility, availability of an elevator, amount of floor space, number of rooms, the availability of amenities, rent level, house ownership etc., is another important objective policy variable for the measurement of elderly housing. These objective housing and neighbourhood characteristics—often translated into targets associated with policy objectives—should be considered together with social indicators regarding the satisfaction of the elderly with housing and neighbourhood variables. Social variables include neighbourhood liveability and satisfaction, fear of crime and potential for social interaction, which are linked to the location, design and management of housing for the elderly. The actual use of neighbourhood facilities and services, patterns of social interaction and the perception and fear of crime are indicators of housing satisfaction for the elderly who are economically and physically limited, more vulnerable and less mobile. Interviews among the elderly population are necessary for planners to study their actual behaviour and perceptions concerning their use of services and their existing and preferred housing situation.

The determinant factor for the perceived housing situation and actual interaction pattern is the household situation. Differentiation in household situation, in terms of age, mobility, cultural-ethnic background and socioeconomic characteristics, causes individual households to perceive the housing environment differently and to weight objective policy criteria differently. This difference in perspectives demonstrates that residential zoning is a relative concept (see Figure 1). A range of friendly to unfriendly zones related to the demographic and socioeconomic characteristics of the elderly population appears to exist.

In theory, the application of the residential quality concept for elderly housing in Dutch—but also European—planning practice can perform several integrative functions, such as:

- (1) a framework for new housing, housing renovation and allocation;



**Figure 1.** The objective policy variables are weighted using interview results and combined with other variables for the development of area-based housing policy.

- (2) a framework for the integration and adjustment of housing, care and service facilities to the needs of the elderly;
- (3) procedures to handle the flow of elderly residents from large to small(er) dwellings;
- (4) a framework for management of the residential environment.

In practice, however, various obstacles may restrict such application. First, it is essential to define the elements of residential quality. Indicators can be provided with different methods (Pacione, 1981). A list of indicators may be established using social planning theory. However, there does not exist a social theory that offers precise conditions defining the residential needs of people. In this context, planning concepts like 'residential zoning for the elderly' can only offer some guidelines for measurement. The second approach is to ask people how they view their residential environment using surveys. This direct method is probably the 'best' method to collect the necessary information; however, it is often time consuming and costly. The third approach involves the collection of 'expert opinions' or the judgements of scientists or representatives of public views. Here, it is possible that the opinions do correspond to the concern of the population under consideration. In fact, the specification of the elements of residential quality should be adapted to local circumstances and the priorities of the local population and organizations. All three methods may support the development of a suitable and comprehensive list of local residential indicators.

The next topic that deserves practical attention is the data collection and data integration. Residential quality indicators can have different data sources, such

as statistical data, survey data, data generated by objective (spatial) models. Another data issue is that objective and subjective indicators can be distinguished (Pacione, 1981). Objective indicators are hard measures that describe the environment in which people live and work, such as health care provision, crime, education, leisure facilities and housing. Subjective indicators are less easy to measure and describe the perception and evaluation of the conditions around people. This might result in weights of the criteria and objectives of individuals or groups (see Rogerson *et al.*, 1989). The integration of objective and subjective indicators needs specific attention. Many individual factors, such as social and socioeconomic characteristics, influence the evaluation of the objective environment. Individual experience leads to different perceptions of objective measures.

Furthermore, indicators and the associated data consist of a different spatial resolution. For residential quality assessment the daily living environment of the elderly consists of the housing location. This implies that the residence, represented by the address or postal code location, is the most desegregated level of measurement. As such, this not only requires large amounts of spatial and non-spatial data, but also the interpretation of this kind of information for policy making requires new methodological considerations, such as aggregation into policy variables. The aggregation of indicators into one element can be employed with different models, such as statistical, mathematical or logical models. The type of measurement technique may also influence possible outcomes.

Thus, measurement of residential quality for the elderly remains an exercise that deserves careful consideration. The choices made regarding the selection of indicators, the aggregation into one index and the weighting or non-weighting of indicators can easily lead to a bias in the results (Pacione, 1981).

In several pilot studies conducted in residential districts in the cities of Amsterdam and Utrecht the research framework illustrated in Figure 1 has been applied for the assessment of residential areas for the elderly to support policy development for elderly housing. A GIS was applied as a data integrator and visualizer in various elements of the research framework, such as qualifying neighbourhood areas based on accessibility indicators, selection and display of suitable dwellings, integration of data on elderly social interaction and attractiveness of collective areas. The next section will outline some important aspects of such computer-based support for monitoring residential quality.

### Computer-based Support for Monitoring Residential Quality

In information technology many types of computer-based systems exist to support operational and managerial decision-making tasks, such as Data Processing Systems (DPS), Management Information Systems (MIS), Decision Support Systems (DSS), Expert Systems (ES) and Executive Information Systems (EIS). The differences between these systems are often explained by the level on which policy and decision making is supported. For the purpose of this paper a DSS approach is adopted as being a computer-based instrument that offers policy and decision makers access to indicators and strategic information based on data and various models. These indicators can be compared with the dashboard of a car or the identifiers in a cockpit: they support the driver in making decisions concerning vehicle navigation. The literature on DSS is rich and many definitions of DSS exist. In the context of this paper the functional

definition of Mittra (1986) offers a consistent framework: "A Decision Support System, DSS for short, is a computer-based information system that helps a manager providing him or her with all the relevant data in an easily understandable form. As the user of a DSS, the manager formulates the problem by using an interactive and probably menu-driven front end. The system then accesses a data base to locate the necessary data, utilizes a repertoire of mathematical and/or statistical models and finally produces the desired information at the user's terminal" (Mittra, 1986, p. vii). An important component of this DSS definition, besides models and user interaction, is the database. Especially for urban planning problems, a DSS should offer possibilities to represent geographical space and the objects in geographical space in order to analyse spatial relations and patterns. The technology that handles spatial data is known as GIS (Geographical Information Systems). GIS is an information technology that offers capabilities to store, maintain, analyse and display spatial data. The various characteristics, spatial and non-spatial, of the geographical objects in planning can be integrated using specific GIS data structures. These data structures give easy access to the construction of geographical measures and concepts such as distance, connectivity, contiguity, accessibility, etc., that form part of urban models (Scholten & Stillwell, 1990). At the same time map display capabilities of GIS have led to possibilities for interactive modelling and exploratory data analyses through computer graphics (Haslett *et al.*, 1990). The combination of DBMS, DSS, ES and GIS has resulted in the concept of Spatial Decision Support Systems (see Densham & Rushton, 1988; Densham, 1990), as the spatial equivalent of DSS. These computer-based systems may also play an important role in assisting urban planners, policy and decision makers in handling large amounts of data and models involved in residential policy analysis (see also Aybet, 1986). Such an automated instrument should offer users efficient access to the data, methods and models needed to generate the necessary information for solving residential planning problems. An essential requirement is the supporting role of the system in all stages of the public policy and decision-making process. First, ongoing monitoring of the significant characteristics of the urban system should be provided. Monitoring provides information concerning the effects of past public policy and problem situations that may call for new policies or actions. The second stage of policy analysis has an input from the monitoring process and specifies the problem, policy objectives, decision criteria and alternative solutions. The final step considers the alternative solutions and evaluates their costs and effectiveness. This three-level rational paradigm of policy analysis forms a continuing process with feedback and iterative procedures of monitoring significant measures and indicators (Calkins, 1992).

The objective of a policy and decision support system is to support public policy through analysis. The evaluation and monitoring functions in policy analysis are often vulnerable elements in policy analysis owing to the long-term period involved in implementation of social and economic policies. Long-term implementation asks for a continuing process of data collection to support these activities (Calkins, 1992).

Besides the fact that a policy support system should consider all stages of policy analysis, it should meet the condition of quantification of the significant policy attributes. Some of the methodological and data-orientated difficulties of quantification of the urban residential system have already been outlined above. An important condition for the acceptance of a policy support system is the



willingness of planners, policy and (political) decision makers to accept quantified targets in policy making. The transformation from general policy statements into direct measurable policy indicators often requires a process of acceptance and adoption. It should also be noticed that public policy making might be influenced by private organizations. Public decision making can only affect private actions indirectly and therefore the effectiveness of a monitoring system may be limited.

### **RELEVANT: Residential Location Evaluation and Analysis Tool**

RELEVANT is a computer-based system developed to support policy making for elderly housing in The Netherlands. RELEVANT has a data model for the storage of the different types of geographical objects that represent the urban residential environment. Furthermore, procedures for selection, aggregation, classification and display of spatial and non-spatial data are available. Various spatial and decision models offer possibilities to create new information from existing data and evaluate the outcomes. A Graphical User Interface (GUI) using multiple windows and views is offered to the user to interact with data and models. The system architecture of RELEVANT is outlined in Figure 2. The interactions between the different systems show that the user of RELEVANT, who communicates with the policy makers and decision makers, has access to RELEVANT through a data, a model and a query input system. The user-defined specifications that are related to data, models and queries are stored in a combined data and modelbase system. When the user needs specific (model-based) data then the query system will be used. Through a query the data and modelbase and modelling/analysis system are activated. Furthermore, through a data export system results of modelling exercises can be integrated with other applications (for instance for statistical analysis).

The following paragraphs outline the data (model), modelling capabilities and user interface of RELEVANT in more detail.

#### *Data for RELEVANT<sup>1</sup>*

Geographical objects from the real world have various types of attributes. For the representation of phenomena that play a role in the daily housing environment of the elderly several types of attributes can be considered (see Figure 3): temporal, thematic, spatial, graphical and even sound. In GIS spatial attributes in particular contribute towards the powerful integration, analysis and cartographic display of data. The geometric attributes give real-world objects an absolute position in space by (sets of) coordinates and the topological attributes (containment, adjacency, connectivity) give objects their relative position. Both types of attributes are fundamental to effective use of GIS for spatial modelling, analysis and map display.

The representation of geographical phenomena in RELEVANT is build upon a two-dimensional Euclidean space with the three geometric types of representation: points, lines and polygons. Each geographical object has one (or more) geometric attributes depending on spatial level and resolution, purpose of the system under consideration, data availability etc. For instance, houses, the most desegregate level for residential quality assessment, can be represented geometrically by polygons (representing the perimeter of the associated parcel) or point

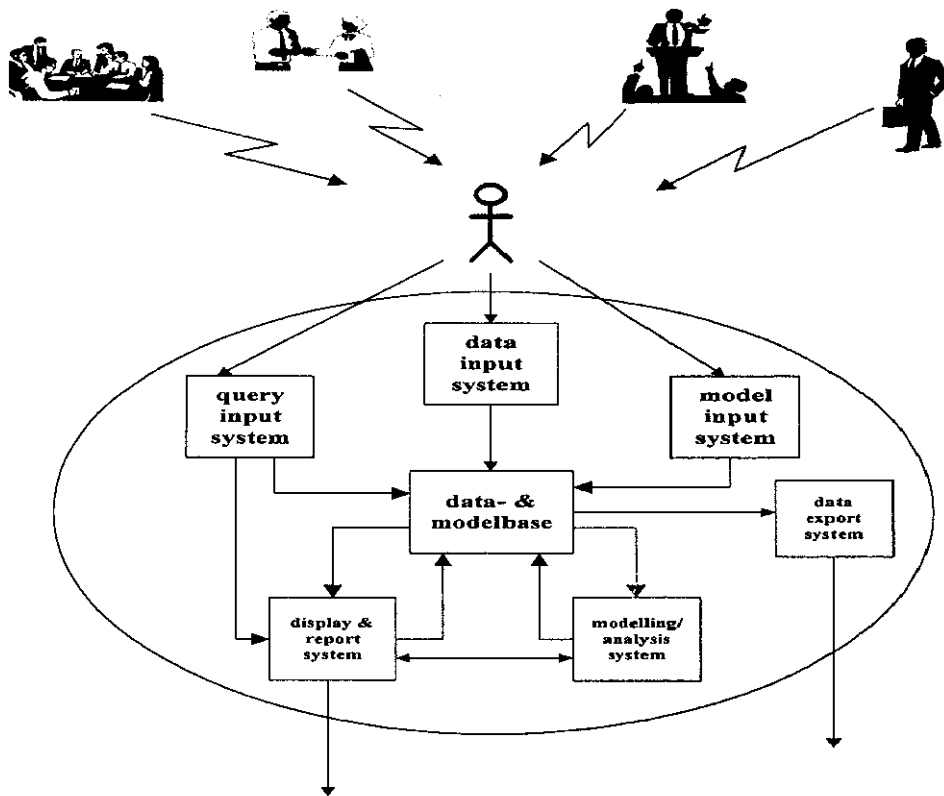


Figure 2. System architecture of RELEVANT.

locations (the centroid or  $x$ - $y$  coordinates of the parcel). This type of large-scale spatial data is in many European countries available through digital cadastral systems.

Another available basic georeferencing level for objects in the urban residential system is the postcode system (see Raper *et al.*, 1992). For postal code data different spatial levels of resolution exist, depending on the number of digits. In The Netherlands the six-digit postcode is the lowest aggregation level representing an average of 15 households. This postal code georeferencing system is also based on the centroid of the underlying parcels. Besides the parcel-centroid georeferencing system, there also exist grid-based referencing systems.

Another way of representing detailed urban data is by street-level representation. With street-level data houses and residences are georeferenced via so-called address matching. At the same time street data are supportive in accurate modelling of transport and traffic interactions (network analysis).

Administrative databases with data on population are, besides the address and postcode level, often only available in aggregated form (administrative areas, such as districts, census tracts, neighbourhood). The spatial levels also play an important role in planning, policy and decision making.

Data concerning the residential environment consist of other geographical objects and phenomena. Besides housing all kinds of other located activities and land uses should be taken into consideration. Shopping, recreation, transport, social interaction and crime are activities that influence residential quality. These

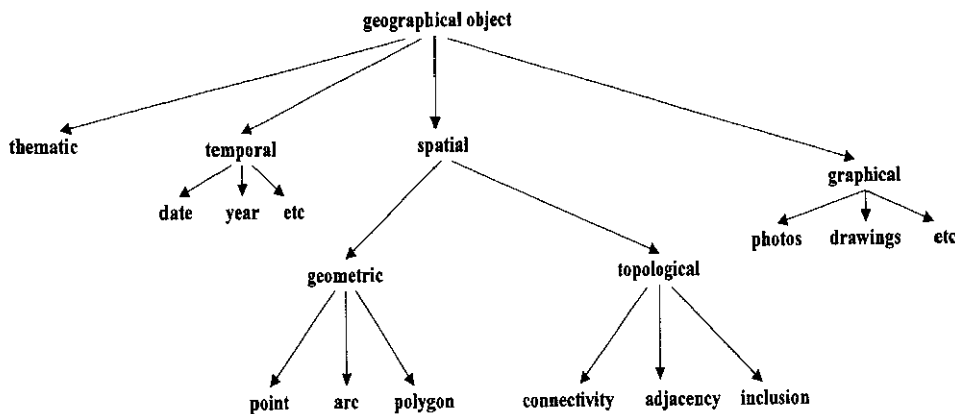


Figure 3. Types of attributes of geographical objects.

activities are also geographically bounded and referenced by various geo-reference systems: cadastral, postcodes, street-based, topographic, boundaries of administrative areas. These digital systems are available not only in The Netherlands, but in several other European countries.

### Models

Decision support for investment decisions concerning the residential environment is only efficient if the planners and policy makers have (easy and fast) access to reliable information regarding the impacts of decisions on the quality of the residential environment. To reduce the risks and uncertainties involved in residential planning and to help planners and policy makers in supporting decision making, several analytical methods and models have been developed. From a practical point of view, the main use of analysis and modelling methods is adding value to information (Clarke, 1990). This can take many different forms (see Figure 4).

The most common function of a model is providing a framework for data transformation. These models generate performance indicators using some kind of (simple) arithmetic operation. Data synthesis and updating refers to procedures to merge and link different data sets, to estimate values of missing variables or to update data sets. Monitoring models have the task of monitoring system performance in time and giving a warning in the case that the performance of system components is exceeding predefined performance levels. Forecasting models generate data on future trends (for instance, population forecasts). Optimization models can be characterized by the problems of finding optimal solutions by maximizing an associated objective function considering *a priori* defined constraints. Impact analysis is a function that models perform in order to solve 'what if' questions. Through changes in the characteristics of the urban system, impacts of (potential) actions can be explored. Evaluation models help decision makers to develop and evaluate different scenarios. Using multi-criteria evaluation methods the generated scenarios can be ranked according to the objectives, criteria and weights of the decision maker.

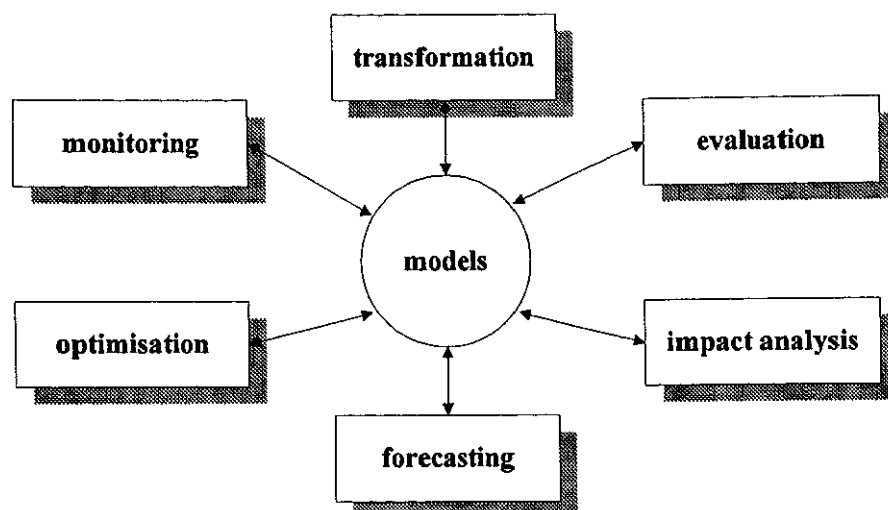


Figure 4. Relation between models and planning functions.

The results from various analytical methods and models will provide the local government with additional relevant information for decision making. This multi-method perspective offers management the information needed to take decisions concerning location problems.

RELEVANT includes several model-based systems that interact with the existing data(bases). Each of the models or systems covers a different perspective on the urban system. Examples of (model-based) systems in RELEVANT are:

- (1) a system to measure various accessibility indicators;
- (2) a system to assess subjective and objective indicators of residential quality;
- (3) a system to monitor residential quality;
- (4) a system to rank spatial alternatives and scenarios using multiple criteria decision analysis.

These subsystems perform functions that can support various residential planning problems. Besides (spatial) models and techniques for data analysis, several GIS-like functions for spatial data manipulation and integration are available. In order to support the integration of data of different spatial resolution, methods of spatial data integration are available in RELEVANT. For instance, for integration of house and neighbourhood indicators, the house indicators should first be transformed into a aggregated neighbourhood index. A point-in-polygon facility identifies the area or neighbourhood that geographically encloses the point. Furthermore, a network topology building facility is available to model flows between point locations in discrete space. Discrete space is represented by a graph or network of nodes that are connected through intermediate arcs. Real-world elements in the urban system, such as houses, stores and streets, are represented as nodes and links in this network. In order to measure transportation costs and impedance measures between two point locations, a network-building facility is available. This facility links the location of a selected set of point locations to the network by adding a link from the initial point

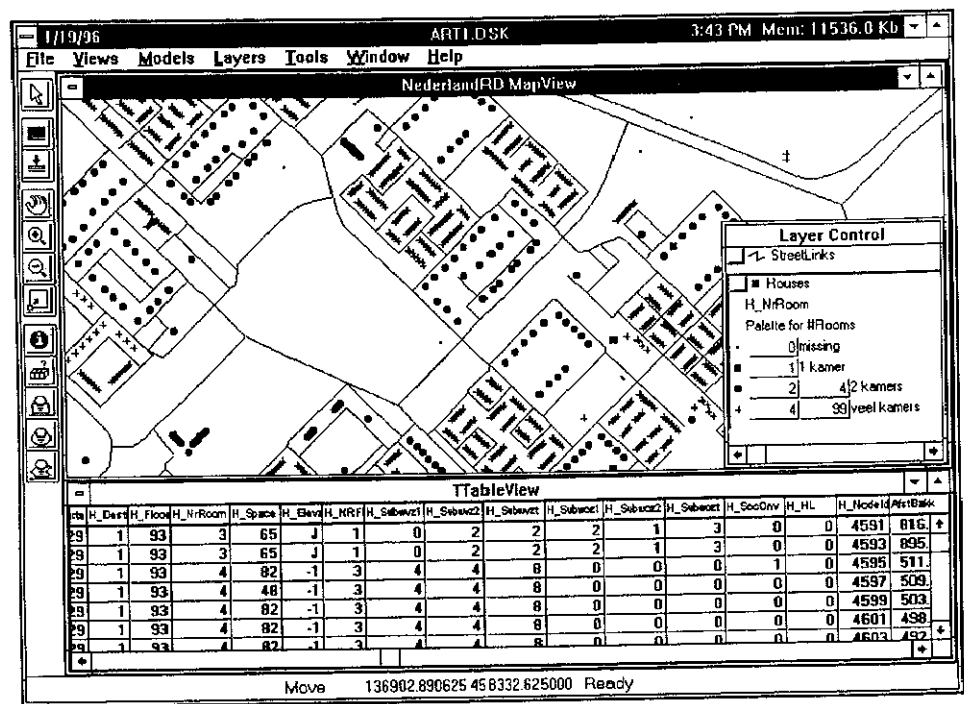


Figure 5. Graphical user interface of RELEVANT with map and table view.

locations to the nearest position on the network. This results in a topological network which is used to measure accessibility indicators based on transportation costs between origin–destination locations using a shortest path algorithm.

An additional facility in measuring origin–destination transportation costs is that it is able to take physical barriers into account. Interactions of the elderly might, for example, be influenced by the occurrence of physical barriers such as railroads, waterways, highways, etc. To restrict interaction flows in the network, nodes can be defined as barriers. As a result impedance will increase or become infinite.

#### User Interaction

An important aspect of the development and use of a computer-based system like GIS is the accessibility of data and models through an easy-to-use interface. Clear presentation of data, modelling estimates and results makes models, which are often difficult to access, more easily accessible and understandable. RELEVANT is accessible through a Graphical User Interface (GUI). Computer interaction through graphics and symbols, e.g. icons, buttons and windows, characterizes this approach. Through mouse-driven specification of system functions and variables, multiple views on data and modelling results are offered by presenting data in maps, graphs, tables and listings (see Figure 5).

With RELEVANT data can always be accessed through a mapping facility (the mapview). Specific graphical tools for selection and query of data through the mapping facility are available to the user. The display of data in the mapview is controlled through a 'legend', which also offers thematic mapping facilities with user-defined classification schemes. Selection of data can be achieved in two ways. First, data can be selected geographically using the 'toolbox'. This toolbox offers tools to zoom in/out and pan geographically and tools for selection by dragging the mouse in the mapview using graphics (e.g. circle, rectangle, user-defined polygon). This will automatically select all geographical objects of the spatial data sets selected in the 'legend'. The second method to select data is combining geographically selected data with selections on the thematic attributes of geographical objects using query statements. Based on the possibilities of modern computer technology the views are linked in RELEVANT, which also offers possibilities for interactive exploratory data analysis (Haslett *et al.*, 1990; Batty & Xie, 1994).

Another important feature of the user interface of RELEVANT is the formal specification of most system functions and control options. System functions such as selection, aggregation, classification and modelling are functions that often have several specification components (data files, model parameters, constraints). Formal specification of these specification components into one system object make it possible to reuse a specification whenever the user wishes to do so. If a formal specification is changed or another specification is selected, the information in all windows (mapview, tableview, graphview, listview) will be updated automatically. This facility offers the user an easy-to-handle tool to change views of the urban system without being concerned about specification issues all the time. All these specifications have access to one or more attributes of different geographical objects in the database, but always result in values for one attribute of a set of geographical objects. As such these user-defined specifications are stored in the modelbase (classifications, selections, models etc.). When the user needs access to the resulting attribute the specification (classification, selection or model) will be executed using the data available. In particular for repeated analysis and modelling exercises this (modelbase) facility offers effective and user-friendly access to often used functions such as classification, selection and modelling.

### **Application of RELEVANT in Dutch Cities**

Since 1991 the Departments of Gerontology and Regional Economics of the Vrije Universiteit Amsterdam have started several research projects in the field of residential zoning and elderly housing using GIS. We now illustrate the application of RELEVANT for the city of Utrecht. For each dwelling in the district of 'Overvecht' several suitability indices were calculated based on policy objectives and local circumstances. These suitability indicators for housing for the elderly were based on a large set of sub-indicators. Accessibility to various types of facilities and service centres, and the (physical) characteristics of dwellings as well as several subjective indicators were combined into a suitability range.

First of all, from the standpoint of accessibility, the following retail and recreational facility and care services are important to the elderly, according to

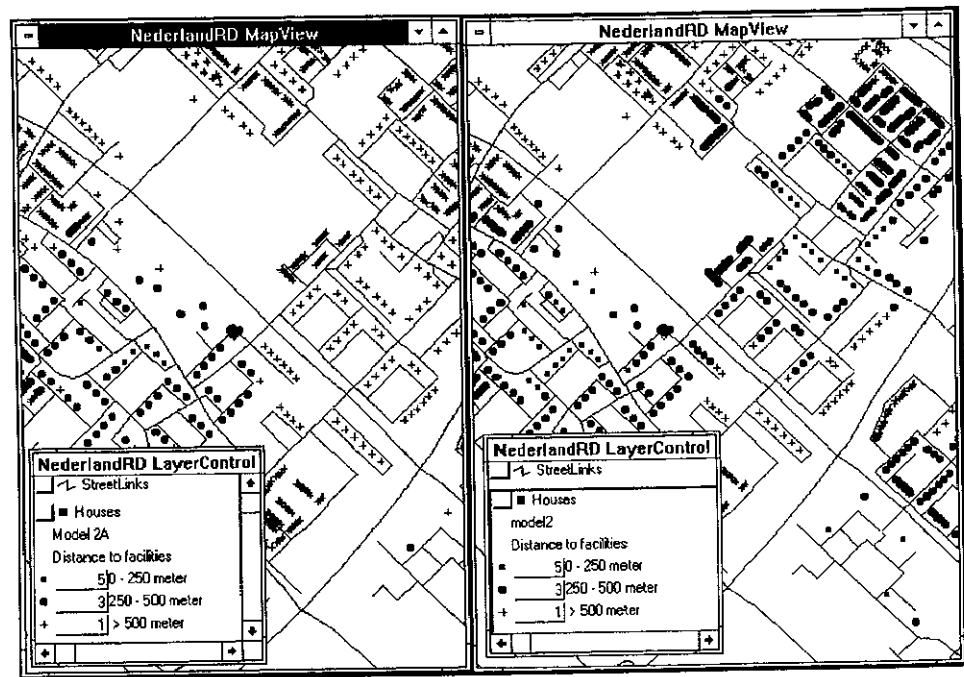


Figure 6. Residential suitability for elderly housing of residential zones in 'Overvecht' district, Utrecht.

Dutch and local planning objectives (in descending order of importance):

- (1) daily visited retail facilities (bakery, greengrocery, butcher's shop, dairy, supermarket and daily market);
- (2) public transport (bus, tram, metro);
- (3) financial services (post office or bank);
- (4) recreational facilities (park and green areas); and
- (5) several care/welfare service centres.

Accessibility for the elderly has been defined as a walking distance of 250 metres for the less mobile elderly and 500 metres for the mobile elderly. Furthermore, housing suitable for the elderly should also have the following characteristics: on the ground floor, first floor or in a building with an elevator, with 2, 3 or 4 rooms, more than 32 m<sup>2</sup> of floor space and a low rent level.

Data concerning the location and type of facilities and care services centres, and the location and characteristics of the housing supply had been collected and stored as point data in RELEVANT. Using the street as a transportation network, distances (using shortest path routines and physical barriers) between all residential locations and every single retail facility and care service centre were calculated. Using policy variables and weights, this information is processed and displayed in several residential suitability maps (see Figure 6).

On the basis of interviews among elderly residents, the weighting was adapted to local circumstances. The elderly expressed their preference and their frequency of use of the different types of facilities and service centres. Using different weighting methods and the weighted summation method of multiple

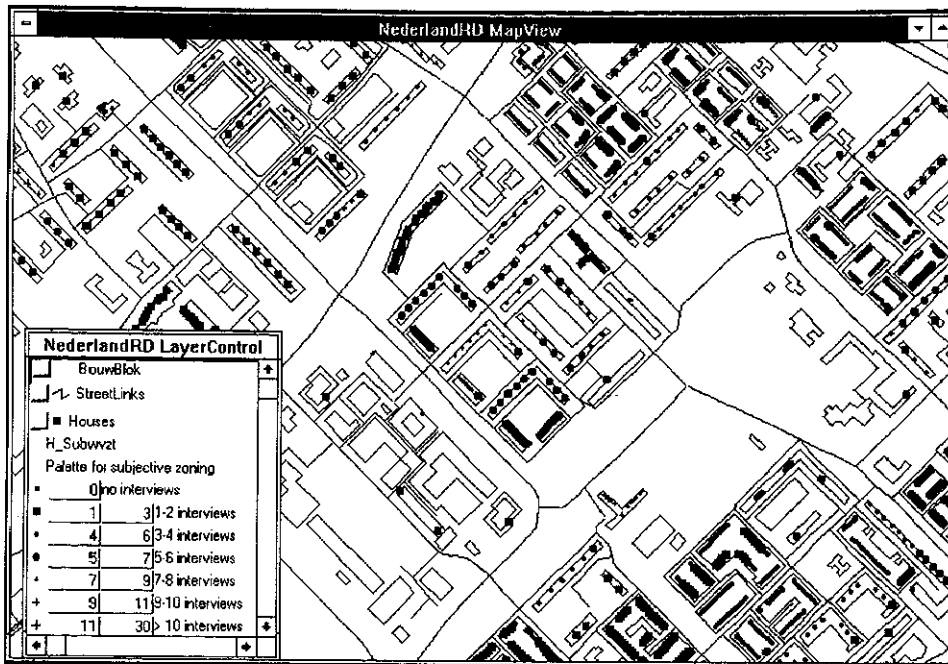


Figure 7. Attractive areas in 'Overvecht' district, Utrecht.

criteria analysis, a classification was derived, based on the product of weights and the distance between residential location and facility location. Shopping and recreation facilities available to the elderly in the neighbourhood were measured by counting the number and type of shops within variable distance zones from residents' dwellings. Using the average distance, a qualification of dwellings according to the neighbourhood service level was generated.

The relationship between the household situation and the spatial component of activities of older individuals was also examined, using a behavioural analysis of elderly. Data on spots and places that the elderly visit regularly, so-called 'habitats', have been collected from interviews with individual elderly people to establish commonly visited areas in the neighbourhood. Data concerning spatial and social interaction by type (shopping, visiting friends etc.), origin-destination and frequency were collected, stored and analysed in RELEVANT. The interaction maps were combined using spatial data integration techniques (e.g. overlay operations) and collective areas of interaction were defined and differentiated for the household situation (age, mobility etc.). Measuring the 'habitat' of the elderly is important to understand the actual interaction and was used to correct policy variables of accessibility to the local circumstances.

At the same time, this information is combined with information about 'attractive' and 'less attractive' areas gained during interviews among governmental, care and welfare institutions and elderly inhabitants. As a result, maps of attractive and less attractive areas, based on the perception and occurrence of crime, were compiled and stored (see Figure 7).



These maps reflect the mental and social perception of elderly individuals and indicate the parts of the neighbourhood they perceive as decent living environments. In combination with objective policy variables, these maps aid in the development of new local plans to improve the housing environment of the elderly. Some of these plans have already been implemented.

Application of this technique in several urban districts in the cities of Amsterdam and Utrecht in The Netherlands clearly illustrates the potential of GIS for residential zoning, behavioural analysis and policy development and support (Grothe & Blom, 1992). Not only local government authorities but also care service institutions, housing corporations and real estate owners can benefit from this concept and gain support for their elderly-housing policy. GIS use in this regard is inevitable. Based on these experiences and results, discussion is now going on for a large-scale implementation of the system in the cities of Amsterdam and Utrecht.

### Concluding Remarks

This paper has paid attention to modern ways of facilities planning for specific urban target groups, i.e. the elderly. Local quality of life seems to be a source of major concern. Tailor-made information is then of critical importance for effective policy analysis. Residential planners require fast and easy access to large amounts of subjective and objective (spatial) indicators for monitoring the impacts of private market developments and public policy. In this paper a GIS-based policy support system has been presented that can help urban planners and policy makers to support decision making regarding residential planning problems. Although the system was originally developed to support planners and policy makers in the field of elderly housing, it offers much greater generality and applicability. This monitoring system does not offer exact solutions to the problems that urban planners are facing, but gives them a set of automated tools and decision aids to explore and structure planning procedures in order to maintain residential quality.

Several advantages may be expected from the integration of large spatial databases, modelling systems and GIS. First, various databases concerning the urban residential environment are linked and integrated through their geographical reference. This may provide new insights and inform strategic policy making. Second, decision makers may have faster access to strategic information to deal with residential planning problems. Third, the integration of GIS and urban planning models, like accessibility models, makes models become (more) available and accessible for urban planning practice. Finally, not only can planners and policy makers in local government have effective support, but also policy makers and individuals in private and public organizations may benefit from it. Access to information for all groups involved in urban planning may improve negotiations and consensus making and hence the quality of decision making.

The methodology presented in the present paper is not based on an *ad hoc* approach, but seeks to map out the most relevant indicators of quality of life for the elderly in their local environment. The analytical framework can easily be used in different circumstances in different places. In this context, RELEVANT offers a new opportunity for monitoring and assessing residential quality for the elderly.

## Notes

1. At the moment many European countries are dealing with their national spatial data infrastructure, from large-scale to small-scale maps. Cadastral data (large-scale maps 1:500 to 1:2000) are already available in many European countries. This type of data is often collected by national cadastral agencies and local government. In several European countries digital topographic maps exist (scale from 1:10 000 to 1:250 000), often collected by governmental agencies. For instance, for Belgium, Switzerland, Austria, Germany, France, The Netherlands and Finland scanned topographical maps (scale from 1:25 000 to 1:1 000 000) are available in digital format. These raster-based maps are used in GIS for visualization purposes. Also, detailed street-level data are available from several commercial suppliers for Belgium, Italy, Finland, Austria, Germany and The Netherlands (scale 1:10 000). Digital spatial systems for postcode data are available in Belgium, Italy, Finland, Austria, United Kingdom, France, Italy, Switzerland, Austria, Denmark, Sweden, Finland and The Netherlands (scale from 1:50 000 to 1:300 000). Also, for many countries, information on administrative boundaries (neighbourhood, districts, municipalities, regions, provinces etc.) exists and is available on the market. It is also clear that the non-spatial, thematic data (e.g. population data) need to be available. However, in almost all countries in Western Europe these data can be used by municipal organizations. Collection takes places either by registration (e.g. The Netherlands) or by census (e.g. United Kingdom).

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